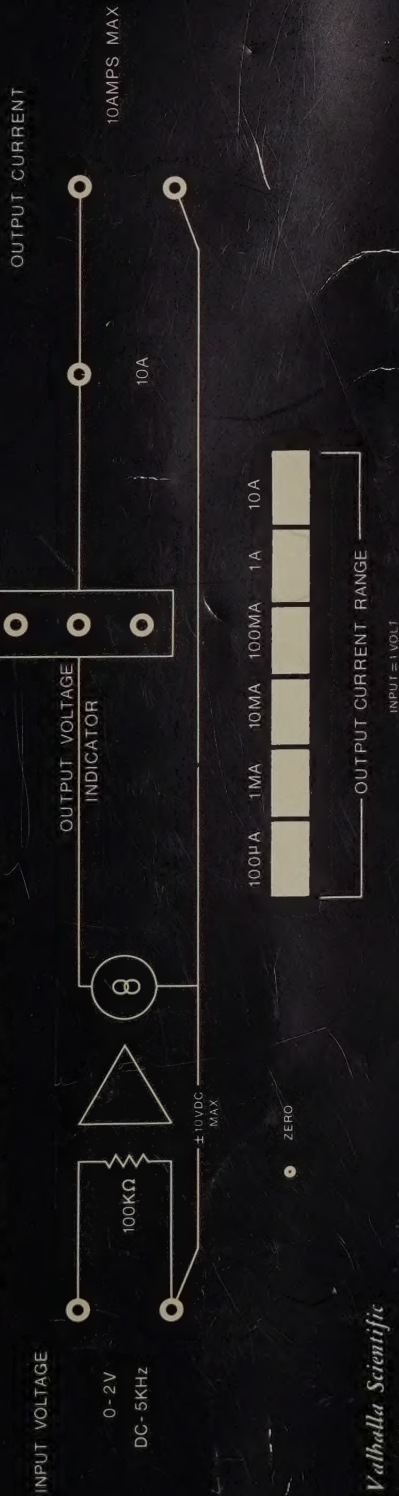


MODEL 2500-E AC-DC CURRENT CALIBRATOR



Valhalla Scientific
SAN DIEGO, CA

INSTRUCTION MANUAL MODEL 2500-E

MP MASTER



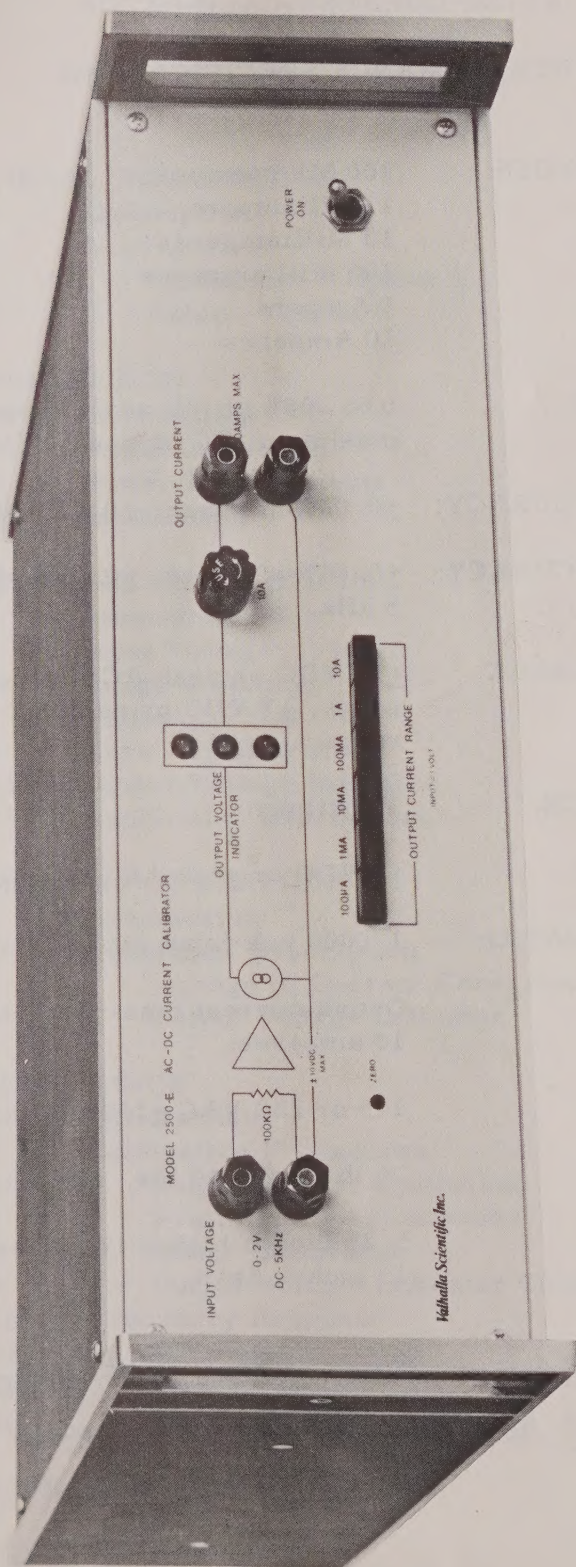
MA25577

CERTIFICATION

Valhalla Scientific Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. Valhalla Scientific Inc. further certifies that its calibration measurements are traceable to the National Bureau of Standards to the extent allowed by NBS's calibration facility.

WARRANTY

Valhalla Scientific Inc. warrants this instrument against defects in material and workmanship for one year from date of shipment. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific Inc. No other warranty is expressed or implied. We are not liable for consequential damages. Permission must be obtained directly from factory for warranty repair returns. No liability will be accepted if returned without such permission.



MODEL 2500-E

AC-DC CURRENT CALIBRATOR

AC-DC CURRENT CALIBRATOR
PERFORMANCE SPECIFICATIONS

FULL SCALE RANGES:	100 Microamperes 1 Milliampere 10 Milliampere 100 Milliampere 1 Ampere 10 Amperes
DYNAMIC RANGE:	0 to 200% of full scale range, 10 amperes maximum (DC or peak AC).
0370 DC CURRENT ACCURACY:	$\pm 0.02\%$ of range, $\pm 0.01\%$ of output.
AC CURRENT ACCURACY:	$\pm 0.05\%$ of range, $\pm 0.05\%$ of output to 5 kHz.
OUTPUT COMPLIANCE VOLTAGE:	± 10 VDC or peak AC through 1 ampere range, ± 7 VDC or peak AC on 10 ampere range.
INPUT IMPEDANCE:	100 kilohms.
INPUT VOLTAGE:	± 3 VDC or peak AC maximum.
INPUT/OUTPUT RATIO:	1.0000 volt input causes full scale output.
PROTECTION:	Output current fuse-protected at 10 amperes.
POWER:	115 or 220 VAC $\pm 10\%$, 50-60 Hz.
WEIGHT:	30 lbs. net, 40 lbs. shipping.
SIZE:	5.25 inches high x 17 inches wide x 15 inches deep.

I CALLED FACTORY & THEY SAID THE SPEC.
IS TYPICALLY MUCH BETTER THAN THE PUBLISHED
SPECS.

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SECTION I

GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The AC-DC Current Calibrator is a complete wide range voltage-to-current converter. This instrument converts a precision input voltage to a proportional output current. The full scale current ranges are selectable in decade increments from 100 microamperes full scale to 10 amperes full scale with the front panel range switch. The AC-DC Current Calibrator is contained in a heavy-duty aluminum case which is ideally suited to the most rugged of requirements.

1-3 ACCESSORIES

1-4 The AC-DC Current Calibrator is shipped from the factory with a detachable power cord and an instruction manual.

1-5 Rackmount - Option R

1-6 This unit may be purchased with an Option R rack mount adapter for use in rack mount applications.

1-7 Cable - Option C

1-8 This unit may be purchased with an Option C Input Cable Set.

SECTION II

INSTALLATION

2-1 INTRODUCTION

2-2 This section contains the information for the inspection and installation of the AC-DC Current Calibrator.

2-3 INITIAL INSPECTION

2-4 The following procedure should be performed on each AC-DC Current Calibrator received from the factory:

1. Before accepting the instrument from the shipping carrier, inspect the shipping container for any signs of external damage.
2. Unpack the instrument and retain the shipping container until the instrument has been inspected for possible damage in shipment.

2-5 POWER REQUIREMENTS

2-6 The AC-DC Current Calibrator operates from 105 to 125 volts AC at 50 to 60 Hertz. To operate the unit from 210 to 250 volts AC, contact the factory.

NOTE

This unit may be purchased from the factory pre-programmed to operate from 220 volts AC.

2-7 INSTALLATION

2-8 The AC-DC Current Calibrator uses a wind-tunnel type heat-sink with a fan. Restricting the flow of air through the unit will cause excessive heating. Caution should be used, especially in rack mount applications, to allow a free circulation of air through the instrument. The maximum air temperature inside the rack must not exceed 50°C. Forced air cooling in the rack is desirable if other equipment dissipates enough power to cause higher internal rack temperatures.

SECTION III

OPERATING INSTRUCTIONS

3-1 INTRODUCTION

3-2 This section contains the complete operating instructions for the AC-DC Current Calibrator. Included is a description of the input, the range switching, the output, and the output voltage indicator.

3-3 INPUT VOLTAGE

3-4 The input voltage controls the output current. If the input voltage is zero, the output current is zero. If the input voltage is ± 1.00000 volt DC, the output current is 100 percent of the selected range (i. e., 1 milliamperes, 10 milliamperes, etc.). If the input voltage is -1.54321 volts DC, for example, the output current is -154.32 percent of range (i. e., -1.5432 milliamperes, -15.432 milliamperes, etc.). The maximum input voltage is 3 volts DC or peak AC. Although the accuracy specification does not define inputs higher than ± 2 volts DC or peak AC, the unit is usable with inputs of ± 3 volts.

3-5 RANGE SWITCHING

3-6 The range switching is accomplished with a six-station push-button switch located on the front panel. This switch selects any one of the six full scale ranges of the instrument. These ranges are defined in decade increments, 1MA, 10MA, 100MA, etc., based on a 1 volt input voltage. For example, if the 1MA range is selected and an input of 1 volt DC is applied, the output is 1 milliamperes DC. If an input of 1 volt rms AC is applied, the output is 1 milliamperes rms AC.

3-7 OUTPUT CURRENT

3-8 The output current is proportional to the input voltage. A 0 to 2 volts input voltage produces an output current of 0 to 200 percent of the selected range. The effective output impedance of the AC-DC Current Calibrator approaches infinity. The output therefore attempts to deliver the selected current into any load impedance applied to the output terminals. An output of 1 milliamperes applied to 1 kilohm produces 1 volt; 1 milliamperes applied to 2 kilohm produces 2 volts, etc., until the output reaches the ± 10 volts DC or peak AC (± 7 volts DC or peak AC for the 10 ampere range). The ± 10 volts DC or peak AC corresponds to 7.07 volts rms AC maximum compliance voltage for sine wave output currents (± 7 volts DC or peak AC corresponds to 4.95 volts rms AC for the 10 ampere range).

3-9 ZERO ADJUSTMENT

3-10 The ZERO adjustment is a screwdriver adjustable potentiometer accessible through a front panel hole to the left of the range switch. The ZERO adjustment is set as follows:

1. Allow the unit to warm up for 1 hour prior to making the ZERO adjustment.
2. Short the input voltage terminals together.
3. Select the IMA range and connect a 1.0000 kilohm $\pm 0.003\%$ resistor across the output terminals.
4. Connect a 5-digit, $\pm 0.003\%$ accurate DVM with a 10^{11} ohm input impedance across the 1.0000 kilohm resistor.
5. Adjust the ZERO control until the DVM displays less than ± 100 microvolts DC.

3-11 OUTPUT VOLTAGE INDICATOR

3-12 The OUTPUT VOLTAGE INDICATOR is an analog type indicator system which informs the operator that the unit is being operated within, near, or beyond the specification limits. The green within-limits indicator is on while the output compliance voltage is less than approximately ± 7 volts DC or peak AC. The yellow near-overload LED indicates when the output compliance voltage is between approximately ± 7 and ± 10 volts DC or peak AC. Note that yellow is the overload indicator in the 10 ampere range because of the 7-volt maximum output compliance voltage. The red overload LED indicates when the output compliance voltage exceeds 10 volts DC or peak AC. This overload indication occurs prior to exceeding the specification limits of the instrument. When the overload indicator is on, the operator should carefully check the test setup to verify proper operating conditions. Even when the output specifications are being exceeded, the overload indication does not necessarily indicate a non-linear operating condition.

3-13 APPLICATION INFORMATION

3-14 The application of a precision constant current source requires a knowledge of potential outside error sources. The following paragraphs outline some of the more common error sources.

3-15 When measuring DC current, there are two primary potential error sources. The first potential error source occurs at the voltage input to the AC-DC Current Calibrator. This error source is caused by the source impedance (R_S) of the input voltage source (Figure 3-1) forming a resistive divider with the 100 kilohm input impedance (R_I) of the AC-DC Current Calibrator. To maintain 0.01 percent error or less, the ratio of $R_I:R_S$ must be 10,000:1 or greater. Since R_I equals 100 kilohms, the maximum impedance for R_S must be less than 10 ohms. The second potential error source occurs at the current output. This error source is formed by the shunt impedance (R_Z) of the DVM (Figure 3-1) in parallel with the load impedance (R_L). To maintain 0.01 percent error or less, the ratio of $R_Z:R_L$ must be 10,000:1 or greater. If the input impedance of the DVM is 10 megohms, the maximum shunt impedance is 1 kilohm. For a shunt impedance of 1 megohm, the input impedance of the DVM must be 10,000 megohms or greater.

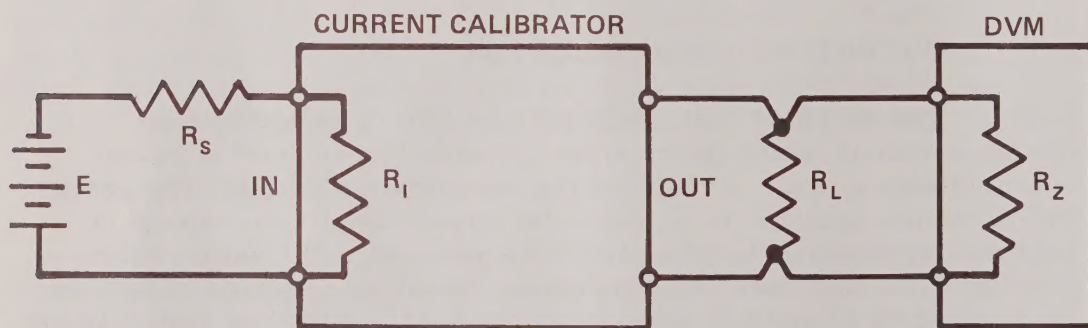


FIGURE 3-1. DC INTERCONNECT DIAGRAM

3-16 In addition to the two previously outlined error sources, several new error sources are formed when measuring AC current. The first and most common of the error sources is cable capacitance C_C , shown in Figure 3-2. If the output current is connected to the load resistance (R_L) through five feet of RG58A/U cable, for example, the cable capacitance is 150 picofarads. If the output frequency is 5 kiloHertz and the load resistance (R_L) is 10 kilohms, the effective load impedance is:

$$Z = \frac{R_L \left(\frac{1}{2\pi \cdot 5 \text{ kHz} \cdot 150 \text{ pf}} \right)}{\sqrt{R_L^2 + \left(\frac{1}{2\pi \cdot 5 \text{ kHz} \cdot 150 \text{ pf}} \right)^2}} = 9.989 \text{ kilohms}$$

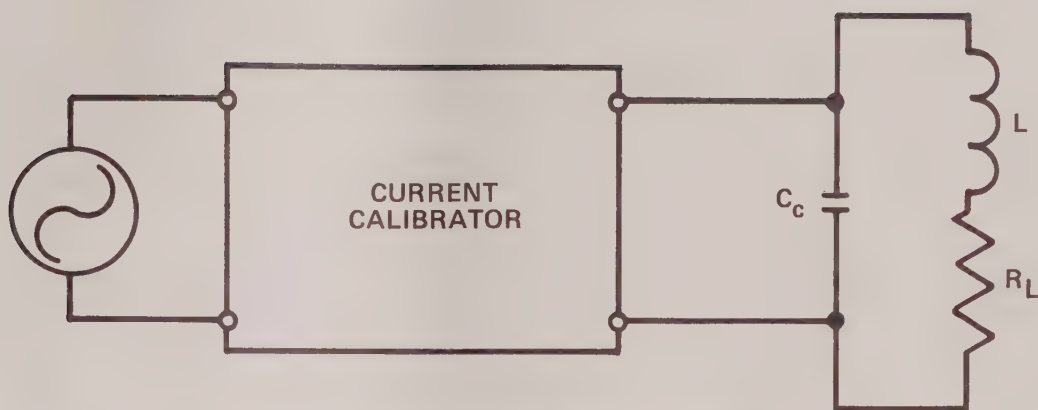


FIGURE 3-2. AC INTERCONNECT DIAGRAM

The effective error due to shunt capacitance (C_C) in this case is 0.11 percent. As shown in the above equation, shunt capacitance versus load impedance is a square law function. Reducing the load impedance by a factor of 10 (10 kilohms to 1 kilohm) reduces the error by a factor of 100 (0.11 percent to 0.0011 percent). Another potential error source is caused by series inductance (L) in the load resistor (R_L). If the load resistance is 0.1 ohm at DC, and the series inductance is 0.5 microhenrys, the effective load impedance at 5 kiloHertz is:

$$Z = \sqrt{R_L^2 + (2\pi \cdot 5 \text{ kHz} \cdot 5 \mu\text{H})^2} = 0.10123 \text{ ohm}$$

The effective error in load impedance caused by series inductance is, in this case, 1.23 percent. A precise 10.000 ampere rms output current at 5 kiloHertz from the AC-DC Current Calibrator applied to this load produces a voltage drop of 1.0123 volts rms AC. In actual practice, series inductance only becomes a problem for shunt impedances of less than 3 ohms at frequencies of 5 kiloHertz. Most of the commercially available laboratory-standard 1-ohm resistors are not low enough in series inductance to be accurate at 1 ampere, 5 kiloHertz. Special non-inductive precision current shunts are required to check the frequency response of the 1 ampere and 10 ampere ranges of this instrument.

SECTION IV

THEORY OF OPERATION

4-1 INTRODUCTION

4-2 The AC-DC Current Calibrator converts a precision input voltage into a precision output current.

4-3 FUNCTIONAL DESCRIPTION

4-4 Figure 4-1 shows a block diagram of the AC-DC Current Calibrator.

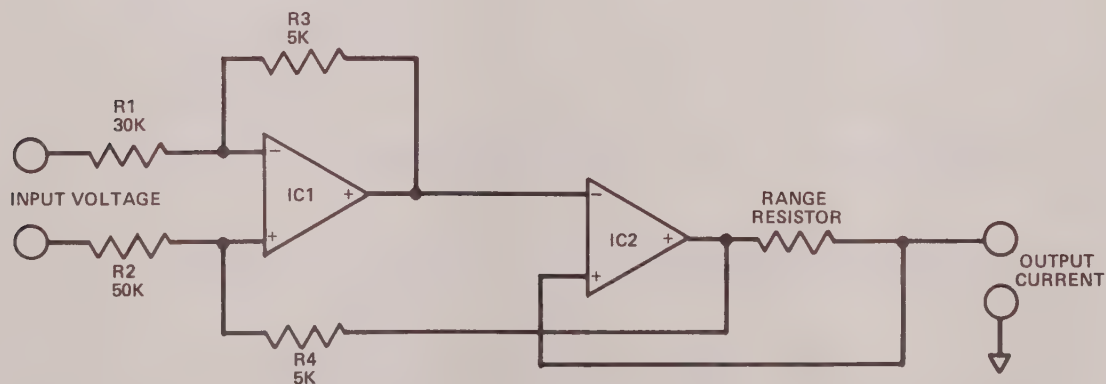
4-5 Voltage to Current Converter

4-6 The input voltage is applied to the input of IC1 through R1 and R2. An operational feedback loop is applied locally around IC1 through R3 to form a differential reference amplifier with a gain of one/tenth. A potentiometric feedback loop is formed by R4 from the output of the second amplifier. The resulting output voltage at IC1, pin 6, is one/tenth the magnitude of the applied input voltage, referred to the output of the second amplifier. This differential reference voltage is applied to the inverting input of the second amplifier. The second amplifier consists of two sections: a high gain voltage amplifier, IC2, and a gain of one current amplifier, Q1 through Q14. The output of the second amplifier is connected to the range resistor network, R47 through R58. With the front panel range switch, a portion of this network is switched into the current path to the output terminals. As a result, one/tenth of the input voltage is differentially impressed across the selected range resistors to produce a precise output current.

4-7 In the 10mA range, for example, a 1.00000 volt input with a short across the output terminals causes the 10 milliamperes to be developed across range resistors R55, R56, R57, R58, and part of R48. The potentiometric feedback through resistor R4 causes the output of operational amplifier IC1 to be at zero volts. The feedback through resistor R28 causes the output of the second amplifier to be 0.10000 volt. Placing a 1 kilohm resistor across the output requires that the output compliance voltage be raised to 10 volts to maintain the 10 milliamperes output current. The potentiometric feedback through resistor R4 now causes the output of operational amplifier IC1 to be at 10.0000 volts. The feedback through resistor R28 now causes the output of the second amplifier to be 10.1000 volts. 0.1000 volt of this potential is dropped across the range resistors and 10.0000 volts is the output compliance voltage.

4-8 Output Voltage Indicator

4-9 The front panel OUTPUT VOLTAGE INDICATOR LEDs provide one of three indications: green - output voltage below 7 volts, yellow - output voltage between 7 and 10 volts, and red - output voltage above 10 volts. The voltage at the output of operational amplifier IC1 is the same as the output compliance voltage. When this voltage is below 7 volts in either polarity, pins 1 and 14 of operational amplifier IC3 are near -7 volts DC and pins 7 and 8 of operational amplifier IC3 are near -15 volts DC, which cause pins 1 and 7 of operational amplifier IC4 to be near -15 volts DC. This turns off red LED DS3 and yellow LED DS4 and causes pin 9 of operational amplifier IC4 to be near -7 volts DC, which in turn causes pin 8 of operational amplifier IC4 to be near +15 volts DC and turn on green LED DS5. When the unit output compliance voltage is between 7 and 10 volts in either polarity, either pin 7 or pin 8 of operational amplifier IC3 is near +15 volts DC and causes pin 1 of operational amplifier IC4 to be near +15 volts DC. This turns on yellow LED DS4 and causes pin 8 of operational amplifier IC4 to be near -15 volts DC and turn off green LED DS5. Red LED DS3 remains off. When the output compliance voltage is greater than 10 volts in either polarity, either pin 1 or pin 14 of operational amplifier IC3 is near +15 volts DC and causes pin 7 of operational amplifier IC5 to be near +15 volts DC. This turns on red LED DS3 and causes pins 1 and 8 of operational amplifier IC4 to be near -15 volts DC and turn off green LED DS5 and yellow LED DS4.



4-1. FUNCTIONAL BLOCK DIAGRAM

SECTION V

MAINTENANCE

5-1 INTRODUCTION

5-2 This section contains the maintenance information for the AC-DC Current Calibrator. Included in this section are the required test equipment lists, calibration procedures, and troubleshooting guide.

5-3 CALIBRATION PROCEDURES

5-4 The following procedures should be performed on a routine basis to ensure that the instrument remains within calibration. The calibration procedures should also be performed after repairs to any of the accuracy determining components.

5-5 Required Test Equipment

5-6 The test equipment required for the calibration procedures is shown in Table 5-1.

Table 5-1. Calibration Test Equipment.

EQUIPMENT	REQUIRED PERFORMANCE
DC Voltage Standard	$\pm 0.003\%$ accuracy, 0 to 1 VDC
5-Digit DVM	$\pm 0.003\%$ accuracy, 10^{11} ohm input Z on 1 VDC range
Precision Shunt Resistors	0.1000 ohm $\pm 0.003\%$ 1.0000 ohm $\pm 0.003\%$ 10.000 ohm $\pm 0.003\%$ 100.00 ohm $\pm 0.003\%$ 1.0000 kilohm $\pm 0.003\%$ 10.000 kilohm $\pm 0.003\%$

5-7 Preliminary Adjustments

1. Apply AC power and allow one hour for the instrument to warm up.
2. Short the input terminals of the AC-DC Current Calibrator together.
3. Select the 1mA range.
4. Connect the 1.0000 kilohm resistor to the output terminals.
5. Connect the DVM across the 1.0000 kilohm resistor.
6. Adjust the AC-DC Current Calibrator front panel ZERO control until the DVM indicates less than ± 100 microvolts DC. This represents 1 microampere or less of output current. The zero adjustment need be performed on only one range. If the ZERO control reaches one end of the adjustment range before the specified DVM reading is reached, perform the following procedure:
 - a. Set the ZERO control to the center of its range.
 - b. Adjust coarse zero control R9 until the DVM indicates less than ± 1 millivolt DC.
 - c. Repeat Step 6.

5-8 Range Calibration

1. Connect the output of the DC Voltage Standard to the input of the AC-DC Current Calibrator.
2. Adjust the DC voltage Standard for an output of 1.0000 volts DC $\pm 0.003\%$.
3. Select the 1 volt DC range on the DVM.
4. 10 Ampere Range. Select the 10A range and connect the 0.1000 ohm resistor to the output. With the DVM across the precision resistor, adjust R58 until the DVM indicates 1.00000 ± 30 digits.

5. 1 Ampere Range. Select the 1A range and connect the 1.0000 ohm resistor to the output. With the DVM across the precision resistor, adjust R56 until the DVM indicates 1.00000 $\pm$ 30 digits.
6. 100 milliampere Range. Select the 100MA range and connect the 10.000 ohm resistor to the output. With the DVM across the precision resistor, adjust R54 until the DVM indicates 1.00000 $\pm$ 30 digits.
7. 10 Milliampere Range. Select the 10MA range and connect the 100.00 ohm resistor to the output. With the DVM across the precision resistor, adjust R52 until the DVM indicates 1.00000 $\pm$ 30 digits.
8. 1 Milliampere Range. Select the 1MA range and connect the 1.0000 kilohm resistor to the output. With the DVM across the precision resistor, adjust R50 until the DVM indicates 1.00000 $\pm$ 30 digits.
9. 100 Microampere Range. Select the 100 μ A range and connect the 10.000 kilohm resistor to the output. With the DVM across the precision resistor, adjust R47 until the DVM indicates 1.00000 $\pm$ 30 digits.

5-9 Output Voltage Indicator Calibration

1. Connect the output of the DC Voltage Standard to the input of the AC-DC Current Calibrator.
2. Select the 10MA range and connect a 1.0000 kilohm resistor to the output of the AC-DC Current Calibrator.
3. Select the 10volt DC range on the DVM and connect the DVM across the 1.0000 kilohm resistor.
4. Adjust the DC Voltage Standard for an output of +1.0000 volts DC $\pm$ 0.003%.
5. Adjust +10 volt adjustment R11 down until the red indicator goes off, then back up until the red indicator just comes on.
6. Adjust the DC Voltage Standard for an output of -1.0000 volts DC $\pm$ 0.003%.
7. Adjust -10 volt adjustment R16 down until the red indicator goes off, then back up until the red indicator just comes on.

8. Adjust the DC Voltage Standard for an output of +0.7000 volts DC $\pm 0.003\%$.
9. Adjust +7 volt adjustment R13 down until the yellow indicator goes off, then back up until the yellow indicator just comes on. Note that the green indicator comes on when the yellow indicator goes off and vice versa.
10. Adjust the DC Voltage Standard for an output of -0.7000 volts DC $\pm 0.003\%$.
11. Adjust the -7 volt adjustment R18 down until the yellow indicator goes off, then back up until the yellow indicator just comes on. Note that the green indicator comes on when the yellow indicator goes off and vice versa.

5-10 FREQUENCY RESPONSE

5-11 The frequency response test (Figure 5-1) need not be performed on a routine basis. The frequency response test is an exacting procedure requiring specialized test equipment not found in most laboratories. Before attempting to perform this test, it is recommended that the operator read and thoroughly under Section 3-13, APPLICATION INFORMATION, of this instruction manual. The equipment shown in Table 5-2, or an exact equivalent, MUST be used to perform this test.

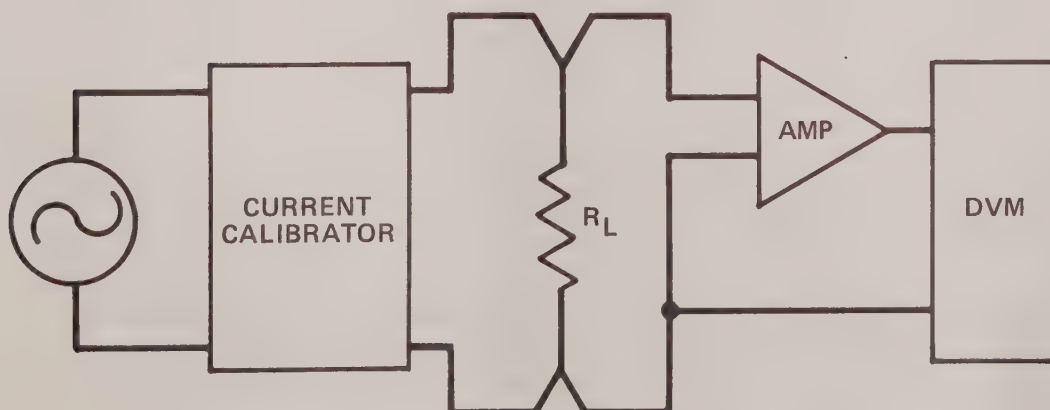


FIGURE 5-1. FREQUENCY RESPONSE TEST

Table 5-2. Frequency Response Test Equipment.

EQUIPMENT	REQUIRED PERFORMANCE
Optimation Model 126 AC Voltage Standard, or equivalent.	0 to 1 volt rms $\pm 0.02\%$, 100 Hz to 5 kHz. Less than 0.01% harmonic distortion. Less than 0.1 ohm output impedance.
Hewlett Packard 3450A001 AC Voltmeter, or equivalent.	$\pm 0.03\%$ accuracy, 100 Hz to 5 kHz on 1 volt range.
Valhalla Scientific Model 2009 AC Amplifier, or equivalent.	10,000 megohms input impedance in parallel with less than 0.5 picofarads capacitance. 0.02% or better frequency response, DC to 5 kHz.
Elliott Industries 157-0.1 ohm current shunt, or equivalent.	10 ampere current shunt, 0.1000 ohm $\pm 0.005\%$. Series inductance 0.0225 microhenrys or less.
Jordon LO-430-1 ohm-SP current shunt, or equivalent.	1 ampere current shunt, 1.0000 ohm $\pm 0.005\%$. Series inductance 0.0225 microhenrys or less.
ESI SR1 current shunt, or equivalent.	100 milliamperes current shunt, 10.000 ohms $\pm 0.005\%$. Series inductance 2.25 microhenrys or less.
Leeds and Northrup Oil Filled Laboratory Resistors, or equivalent.	10 milliamperes current shunt, 100.00 ohms $\pm 0.005\%$.
Leeds and Northrup Oil Filled Laboratory Resistors, or equivalent.	1 milliamperes current shunt, 1.0000 kilohm $\pm 0.005\%$.
Leeds and Northrup Oil Filled Laboratory Resistors, or equivalent.	100 microamperes current shunt, 10.000 kilohm $\pm 0.005\%$. Total shunt capacitance (leads and resistor) 20 picofarads or less.

NOTE

For factory certification of the AC-DC Current Calibrator with NBS traceability, contact your local sales representative or the factory.

5-12 TROUBLESHOOTING

5-13 Difficulties often arise due to misinterpretation of specifications or outside error sources. Carefully check that the instrument is truly malfunctioning before attempting to repair it.

5-14 POWER SUPPLIES

5-15 The ± 22 volt power supply is formed by CR5 through CR8, C2, and C3. The ± 22 volt power supply is unregulated and varies from 18 volts DC to 23 volts DC depending upon line and load. The +15 volt DC power supply is voltage regulator IC5. This supply is typically 15.1 volts DC. The -15 volt DC power supply is voltage regulator IC6. This supply is typically 14.9 volts DC.

5-16 MAIN AMPLIFIER

5-17 Before attempting to service the main amplifier, read the theory of operation section covering its functional description in Paragraph 4-4. The following procedure is only an aid to isolate a catastrophic malfunction to a local area. Short the input terminals together and the output terminals together. With a differential DC voltmeter, measure the voltage between the R4 lead furthest from IC1 and IC1 pin 6. This voltage must be less than 10 millivolts. If not, IC1 is defective. If the voltage is less than 10 millivolts, the malfunction is in the second amplifier or the feedback network.

NOTE

If IC1, IC2, Q1 through Q14, or R47 through R58 are changed, the AC Frequency Response Test must be performed.

Valhalla Scientific Inc

PARTS LIST

REF. DES.	V.S. P/N	DESCRIPTION	MFG.	MFG. P/N
C1	2-20001	Cap. Mica 1800pf	81349	CM06F182J03
C2, 3	2-40003	Cap. Elec. 61000mf 40v	00853	DCM613U0400D2B
C4	2-60005	Cap. Paper 4.7uf	53504	MPE2S-4.7MFD
C5, 6	2-30001	Cap. Tan 10uf/25v	05397	T3060B106M025AS
C7	2-20013	Cap. Mica 100pf	81349	CM05FD101J03
C8	2-20014	Cap. Mica 20pf	81349	CM05FD200J03
DS1, 2, 6	5-01005	LED	00001	MV5074
DS3	5-01011	LED, RED Panel Mtg.	28480	5082-4655
DS4	5-01012	LED, YEL Panel Mtg.	28480	5082-4555
DS5	5-01013	LED, GRN Panel Mtg.	28480	5082-4955
CR1-4	3-20000	Diode	07263	1N914
CR5, 6	3-20011	Diode, Rect.	07263	1N1183A
CR7, 8	3-20012	Diode, Rect. Rev. Pol.	07263	1N1183RA
F1	5-04003	Fuse 3A	75915	3AG 3A
F2	5-04005	Fuse 10A	75915	3AG 10A
IC1, 2	3-30038	IC Op-Amp	27014	LH0052CH
IC3, 4	3-30031	IC Quad Op-Amp	27014	LM324N
IC5	3-30036	IC Reg Pos 15v	27014	LM340T
IC6	3-30037	IC Reg Neg 15v	27014	LM320T
J1, 3	5-10021	Binding Post, RED	83330	257-RED
J2, 4	5-10020	Binding Post, BLK	83330	257-BLK
J5	5-10000	Power Recp.	83234	AC3
Q1	3-10002	Transistor, PNP	04713	2N4036
Q2-7	3-10008	Transistor, NPN PWR	86684	2N3055
Q8	3-10007	Transistor, NPN	86684	2N2102
Q9-14	3-10009	Transistor, PNP PWR	86684	2N6248
R1, 2	1-20034	Res. Fxd. 50K .01%	00002	J110-50K
R3, 4	1-20035	Res. Fxd. 5K .01%	00002	J110-5K
R5, 6	1-10012	Res. Fxd. 20K 1%	81349	RN60C2002F
R7	1-01043	Res. Fxd. 1.5K 5%	81349	RC07GF152J
R8	1-50016	Res. Var. 10K	91637	8781-10K
R9, 50	1-50012	Res. Var. 10K	80294	3255W-10K
R10, 15	1-01053	Res. Fxd. 4.7K 5%	81349	RC07GF472J
R11, 13, 16, 18, 52	1-50013	Res. Var. 1K	80294	3255W-1K
R12, 17	1-01045	Res. Fxd. 2K 5%	81349	RC07GF202J
R14, 19	1-01057	Res. Fxd. 6.8K 5%	81349	RC07GF682J
R20-27, 31, 32	1-01063	Res. Fxd. 15K 5%	81349	RC07GF153J
R28	1-01081	Res. Fxd. 100K 5%	81349	RC07GF104J
R29	1-01041	Res. Fxd. 1K 5%	81349	RC07GF102J
MODEL: 2500E		TITLE: Current Calibrator		SHT OF 1 2

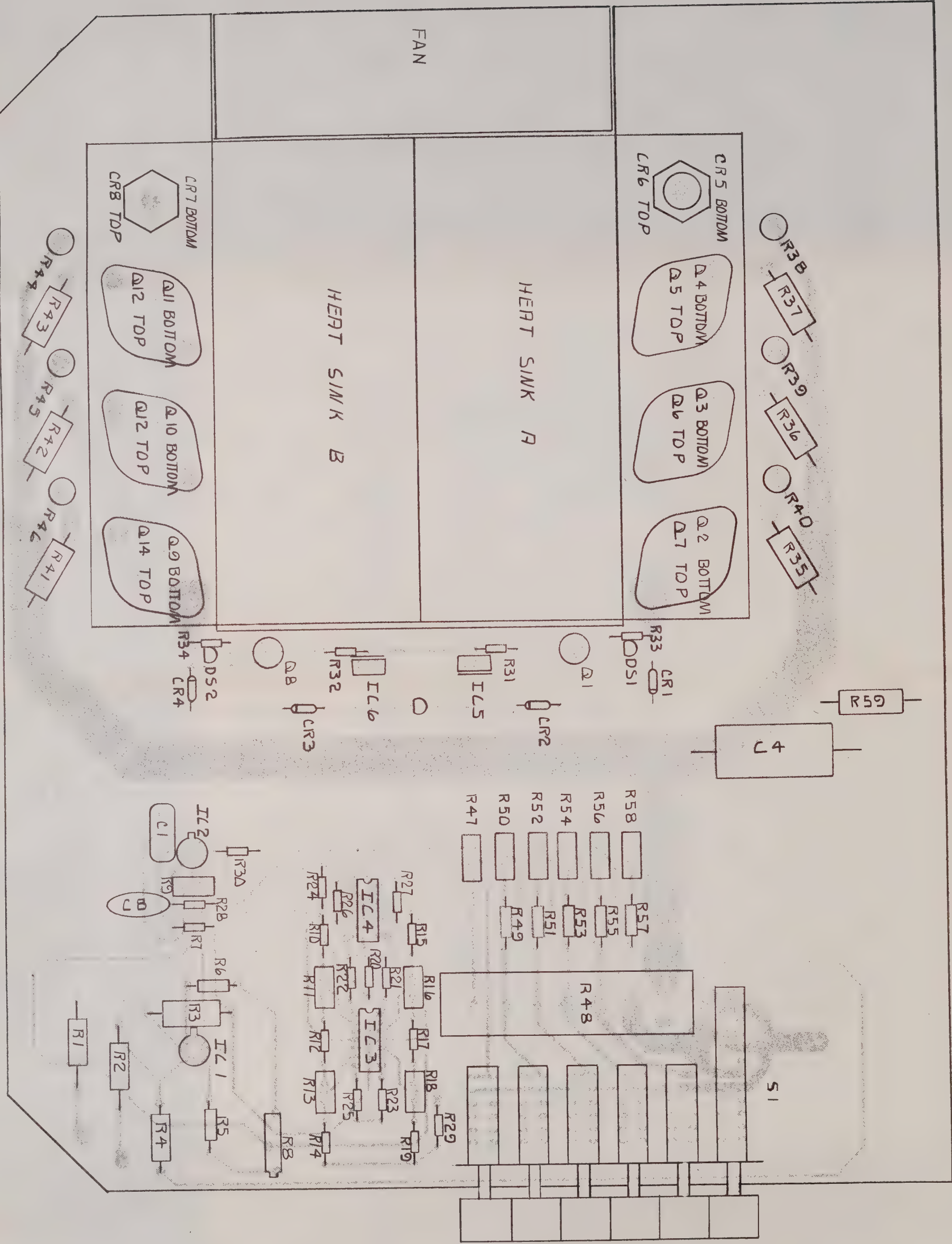
Valhalla Scientific Inc

PARTS LIST

REF. DES.	V.S. P/N	DESCRIPTION	MFG.	MFG. P/N
R30, 35, 41	1-01015	Res. Fxd. 47 ohm 5%	81349	RC07GF470J
R33, 34	1-01021	Res. Fxd. 100 ohm 5%	81349	RC07GF101J
R36-40, 42-46, 59	1-30001	Res. Fxd. 1 ohm 5%	44655	1500-1 ohm
R47, 58	1-50018	Res. Var. 10 ohm	80294	3255W-10
R48	1-20033	Res. Fxd. prec. netwk.	53504	1-20033
R49	1-10042	Res. Fxd. 5.62K 1%	81349	RN60C5621F
R51	1-10043	Res. Fxd. 562 ohm 1%	81349	RN60C5620F
R53	1-10044	Res. Fxd. 56.2 ohm 1%	81349	RN60C56R2F
R55	1-10045	Res. Fxd. 13.7 ohm 1%	81349	RN60C13R7F
R54, 56	1-50014	Res. Var. 100 ohm	80294	3255W-100
R57	1-10046	Res. Fxd. 2.3 ohm 1%	81349	RN60C2R30F
S1	5-03008	Range Switch	53504	5-03008
S2	5-03009	Power Switch	83330	1720
T1	4-20009	Power Transformer	53504	2500-011
1 ea.	4-30015	P.C. Board	53504	2500E-700
2 ea.	4-10049	Heat Sink	53504	2500-206
1 ea.	4-10050	Ground Bracket	53504	2500-207
4 ea.	4-10051	MTG Bracket	53504	2500-208
1 ea.	4-10052	Rear Panel	53504	2500-209
1 ea.	4-10053	Front Panel	53504	2500-210
1 ea.	-	Chassis Assembly	.	B-525-15-1700H
2 ea.	-	Blank Panel	.	16-65004-1
1 ea.	5-10059	Fan, 115VAC 50-60Hz	rotron	MU2A1
2 ea.	5-10060	Finger Guard	rotron	476042
2 ea.	5-10057	Socket 8 pin round		8ICS
2 ea.	5-10041	Socket 14 pin DIP	01295	
12 ea.	5-10005	Standoff	88245	1530B-3/16
2 ea.	5-10018	Fuse Holder		42004A
2 ea.	5-10062	Capacitor Mtg. Bracket	90201	VR12
MODEL : 2500E		TITLE : Current Calibrator		SHT 2 OF 2

FEDERAL SUPPLY CODE
for
MANUFACTURERS CATALOGING HANDBOOK H4-1

00001	Monsanto, Electronic Special Products, Cupertino, Calif.
00656	Aerovox Corporation, New Bedford, Mass
00853	Sangamo Electric Company, Pickens, S.C.
01121	Allen-Bradley Company, Milwaukee, Wisc.
01255	Litton Industries, Inc., Beverly Hills, Calif.
01281	T R W Semiconductors, Inc., Lawndale, Calif.
01295	Texas Instruments, Inc., Dallas, Texas
02335	Fairchild Controls Corp., Hicksville, LI, N.Y.
02660	Amphenol Corporation, Broadview, N.Y.
03507	General Electric Company, Syracuse, N.Y.
04713	Motorola Semiconductor Prod., Inc., Phoenix, Ariz.
04963	3-M, St. Paul, Minn.
05276	Pomona Electronics Co., Inc., Pomona, Calif.
05397	Kemet, Union Carbide Corp., Cleveland, Ohio
05820	Wakefield Engineering, Inc., Wakefield, Mass.
07088	Kelvin Electric Company, Van Nuys, Calif.
07256	Silicon Transistor Corp., Garden City, N.Y.
07263	Fairchild Camera and Instr. Corp., Mt. View, Calif.
07716	I R C, Incorporated, Burlington, Iowa
07910	Continental Devices, Hawthorne, Calif.
08065	Accurate Rubber and Plastics Co., San Diego, Calif.
09026	Babcock Electronics Corp., Costa Mesa, Calif.
12405	Hysol Corporation, El Monte, Calif.
12406	Elpac, Incorporated, Fullerton, Calif.
12697	Clarostat Mfg. Co., Incorporated, Dover, N.H.
13454	Texas Crystals, River Grove, Ill.
14655	Cornell-Dubilier Elect. Corp., Newark, N.J.
14752	Electro Cube, Incorporated, San Gabriel, Calif.
16758	Delco Radio Div., General Motors, Kokomo, Ind.
17838	Mektron, California General, Inc., Chula Vista, Calif.
18324	Signetics, Sunnyvale, Calif.
18722	R C A, Mountaintop, Pa.
21604	Buckeye Stamping Company, Columbus, Ohio
25684	Victoreen Instrument Co., Inc., Oak Lawn, Ill.
27014	National Semi-Conductor Corp., Santa Clara, Calif.
27556	IMB Electronic Products, Santa Fe Springs, Calif.
28480	Hewlett-Packard Co., Palo Alto, Calif.
30983	Electra/Midland, San Diego, Calif.
44655	Ohmite Manufacturing Company, Skokie, Ill.
71279	Cambridge Thermionic Corp., Cambridge, Mass.
71400	Bussmann Mfg. Div., McGraw-Edison Co., St. Louis, Mo.
71450	CTS Corporation, Elkhart, Ind.
71468	ITT Cannon Electric, Inc., Los Angeles, Calif.
71590	Centralab Div., Globe-Union, Inc., Milwaukee, Wisc.
71785	Cinch Manufacturing Company, Chicago, Ill.
73899	J F D Electronics Company, Brooklyn, N.Y.
75915	Littlefuse, Incorporated, Des Plaines, Ill.
76055	Mallory Controls, Frankfort, Ind.
76493	J. W. Miller Company, Los Angeles, Calif.
78488	Stackpole Carbon Company, St. Marys, Pa.
80294	Bourns, Incorporated, Riverside, Calif.
81095	Triad Transformer Corp., Venice, Calif.
81312	Winchester Electronics, Oakville, Ct.
81349	Military Spec., Standardization Division, Chicago, Ill.
82389	Switchcraft, Incorporated, Chicago, Ill.
83330	Herman H. Smith, Inc., Brooklyn, N.Y.
84171	Arco Electronics, Inc., Great Neck, N.Y.
86684	R C A, Harrison, N.J.
88245	Uesco Div., Litton Industries, Van Nuys, Calif.
90201	Mallory Capacitor Company, Indianapolis, Ind.
91637	Dale Electronics, Inc., Columbus, Neb.
91929	Micro Switch Div., Honeywell, Inc., Freeport, Ill.
92194	Alpha Wire Corporation, Elizabeth, N.J.
93332	Sylvania Electric Products, Inc., Woburn, Mass.
98978	IERC, Burbank, Calif.
00002	Jordan Electronics, Van Nuys, Calif.
Val-Sci	Valhalla Scientific, Inc., San Diego, Calif.



MODEL 2500E ASSEMBLY DIAGRAM

PRECISION AC-DC CURRENT CALIBRATOR

MODEL 2500-E

ORDERING INFORMATION

MODEL 2500-E	AC-DC CURRENT CALIBRATOR	\$1495.00
OPTION "R"	RACK MOUNT ADAPTER	25.00
OPTION "C"	INPUT CABLE SET	15.00
MODEL 2009	BUFFER AMPLIFIER	395.00

FOB: San Diego

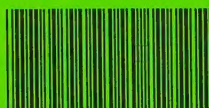
TERMS: Net 30

DELIVERY
Stock to 30 Days

Valhalla Scientific Inc.

7707 CONVOY CT. SAN DIEGO, CALIFORNIA 92111 714-277-2732

MP MASTER



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